AIRCRAFT AIRWORTHINESS STANDARDS FOR CIVIL UNMANNED AIR VEHICLE SYSTEMS

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CIVIL AVIATION AUTHORITY

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Airworthiness of Civil UAVs

A complete “Poster Paper” covering the content of this presentation has been provided for inclusion on the conference CD.

Airworthiness of Civil UAVs

CAA Overall Objective

UAVs will pose no greater risk to persons or property in the air or on the ground than that presented by equivalent manned aircraft.

Airworthiness of Civil UAVs

Existing civil aircraft:

Regulatory environment includes defined standards for:

- Airworthiness, (including Design, Production and Continued Airworthiness Management).
- Qualification of Personnel, (aircrew and groundcrew)
- Operation of Aircraft
- Air Traffic Management
- Etc……

Airworthiness of Civil UAVs

This presentation covers the current CAA policy for the **Airworthiness Certification** and regulation of the **Design and Production** of civil UAVs

(It does not address the standards applicable to the approval of operations etc.).

Airworthiness of Civil UAVs

The future development potential of civil UAVs is unclear in many respects:

- Fleet size
- No limits (high or low) on aircraft size, mass, speed, range, endurance etc.

Any system of regulation we choose must be flexible enough to cope with any number of aircraft of any physical size and capability.

Airworthiness of Civil UAVs

Alternative processes considered:

- Use of “Safety Target” approach;
- Certification by compliance with defined minimum airworthiness standards

Airworthiness of Civil UAVs

Safety Target Approach

- Sets an overall “safety target”, (numerical)
- Focuses on critical features of the system
- Does not rely on commonly adopted design requirements
- Combines operational and design requirements to achieve target – Example: Uncertainty over control system integrity can be addressed by restricting operation to empty airspace over uninhabited regions

Airworthiness of Civil UAVs

Certification by compliance with minimum airworthiness standards.

- Certification by compliance with comprehensive codes of design requirements, (e.g. JAR 23), with added Special Conditions as necessary
- Type Certification of the defined design.
- ICAO Certificates of Airworthiness for aircraft in conformity with the approved design.
- Wherever possible the design requirements do not presume any particular role or mission.

Airworthiness of Civil UAVs

Safety Target or Code of Requirements?

- Expectation is that there will be an overall safety target for the ***Operation*** of UAVs. BUT…….
- Will the ***Airworthiness*** contribution to reaching this target be a fixed, minimum standard, (Code of Requirements); or a variable standard depending upon the role of the particular UAV and the restrictions applied to its operation?

Airworthiness of Civil UAVs

Review of Safety Target Approach.

Use of Safety Target by the military is assisted by the following:

- The Government is both the regulator and the sole "Operator" – Easy to control frequency, duration, and location of operations to be consistent with required safety levels.
- No commercial competition in flying operations.
- Normally military aircraft are designed under contract to the customer – the operator's mission requirements are well-defined at the preliminary design stage

Airworthiness of Civil UAVs

Use of Safety Target approach for civil aircraft would raise the following issues:

- Exports or international operations will require recognition of equivalent standards – Requires agreement by all relevant countries on common Safety Targets and on acceptable methods for the compilation of safety cases.
- Any restriction of frequency, duration, or location of operations upon which the safety case relies may have a direct adverse effect on the profitability of the Operator. (Profit vs Safety).

Airworthiness of Civil UAVs

Use of Safety Target for civil aircraft - Issues - Continued:

- Civil aircraft are designed to appeal to as many potential customers as possible. Designing to particular missions may damage sales prospects.
- Any need to operate over populated areas may require a very demanding Safety Target; it may not be possible to provide sufficient data to justify that it will be achieved.

Airworthiness of Civil UAVs

Existing legal framework for civil aircraft airworthiness

International conventions and treaties and the National Legislation of all ICAO Member States have the in-built assumption that civil aircraft will have –

Certificates of Airworthiness granted on the basis of compliance with appropriate standards of design and manufacture consistent with ICAO Annex 8

Airworthiness of Civil UAVs

Safety Case - Summary

Advantages:

- No need for comprehensive code of requirements
- Focus on safety critical areas
- Allows less demanding design standards if all operations will be away from 3rd parties

Disadvantages:

- Design assumptions valid for anticipated missions only. Change of mission may need a completely new safety case/re-design
- Reliance on operational restrictions to address shortfalls in airworthiness conflicts with commercial viability
- Not consistent with ICAO and national legislation

Airworthiness of Civil UAVs

Code of Requirements for Certification - Summary

Advantages:

- Clarity over commonality of standards – Facilitates mutual recognition of standards for export sales and international operation.
- Role/mission changes can take credit for certification of basic vehicle, reducing re-certification costs and timescales
- No special, type-specific, operating restrictions to address airworthiness uncertainties – Greater operational freedom – Avoids conflict between safety and commercial gain.

Airworthiness of Civil UAVs

Code of Requirements for Certification - Summary

Advantages - continued:

- Familiar to existing civil aircraft industry. Clear minimum standards are defined at the design stage.
- Builds on past experience, giving confidence that the primary objective of “no greater risk” will be achieved.
- Fits existing international legal framework. Equivalence to existing manned civil aircraft standards is a clear and defendable position

Airworthiness of Civil UAVs

Code of Requirements for Certification - Summary

Disadvantages:

- Requires compilation of a “Basis of Certification”/Code of Requirements.
- May be unnecessarily demanding if the aircraft is always to be operated well away from 3rd parties.

Airworthiness of Civil UAVs

Related issues:

- UK industry wants UAV to mean:

  "UNINHIBITED AIR VEHICLE"

  Minimum of operating restrictions - equality with manned aircraft – (Implies Code of Requirements & CofA)

- If the Safety Target is demanding, designers are likely to choose compliance with existing airworthiness requirements as the most expedient means of justifying that the target will be achieved.

Airworthiness of Civil UAVs

Having considered all of these issues the CAA has concluded that civil certification of UAV Systems should follow existing practice for manned civil aircraft. i.e.:

- The design of any civil UAV System should be required to comply with a defined code of airworthiness requirements to achieve “Type Certification”
- Individual UAV Systems will be issued with Certificates of Airworthiness when they show conformity with the approved design

Airworthiness of Civil UAVs

Application of JARs/FARs to UAV guidance systems

- In common with manned aircraft the complete flight guidance system will have to be included in the design certification process.
- All systems and equipment which contribute to or can prejudice airworthiness, whether on board the UAV or not, will be subject to regulation as part of the aircraft.

Airworthiness of Civil UAVs

Airworthiness Requirements for Civil Certification

If UAV Systems are to be certificated by demonstration of compliance with codes of airworthiness requirements, how are we going to compile those codes?

Airworthiness of Civil UAVs

Airworthiness Requirements for Civil Certification

Preamble to ICAO Annex 8 says:

"…the objective of international airworthiness standards is to define..the minimum level of airworthiness…for the recognition of certificates of airworthiness…..thereby achieving, among other things, protection of other aircraft, third parties and property."

i.e. The primary purpose of Annex 8 requirements is the protection of third parties, not the occupants.

Airworthiness of Civil UAVs

Airworthiness Requirements for Civil Certification

So existing manned aircraft codes of requirements, (JARs/FARs), can be considered to be:

- a set of ICAO-related standards for the protection of third parties;

supplemented by:

- cabin safety requirements aimed specifically at the protection of occupants

It follows that a suitable starting point for a UAV code, could be JARs/FARs with the cabin safety requirements deleted, and Special Conditions added to address remote guidance etc.

Airworthiness of Civil UAVs

A proposal to derive UAV airworthiness requirements from manned aircraft codes raises two immediate questions:

- Can the existing JARs/FARs be readily extended to address the autonomous/remote guidance of UAVs?
- There are many JAR/FAR aircraft codes. These include the number of occupants in their applicability criteria. How should we select requirements from the existing JAR/FAR codes to construct the certification basis for a particular design of UAV System?

Airworthiness of Civil UAVs

1. Can the existing JARs/FARs be readily extended to address the autonomous/remote guidance of UAVs?

- Civil National Airworthiness Authorities have been very successful in developing the requirements to cope with novel aircraft/technology.
- Modern Civil Large Transport Aeroplanes are highly automated; including automatic fault analysis and corrective action.
- When we have auto-take-off to complement auto-land etc., it may become routine for airliners to complete their missions without a pilot operating the primary flying controls at any stage. i.e. Fully pre-programmed missions.

So we expect to be able to write suitable JARs for UAV control systems; (However, showing compliance with those JARs may be difficult!)

Airworthiness of Civil UAVs

2. How should we select requirements from the existing JAR/FAR codes?

Compiling a Certification Basis is always an iterative process involving:

- Specialist knowledge.
- Experience and judgement.
- Consultation and discussion

But the process needs an initial preliminary proposal as a starting point……

Airworthiness of Civil UAVs

CAA method for obtaining a first estimate of the appropriate airworthiness standards

The capability of a vehicle to harm third parties is broadly proportional to its kinetic energy on impact

Airworthiness of Civil UAVs

CAA method for obtaining a first estimate of the appropriate airworthiness standards - continued

Consider two scenarios:

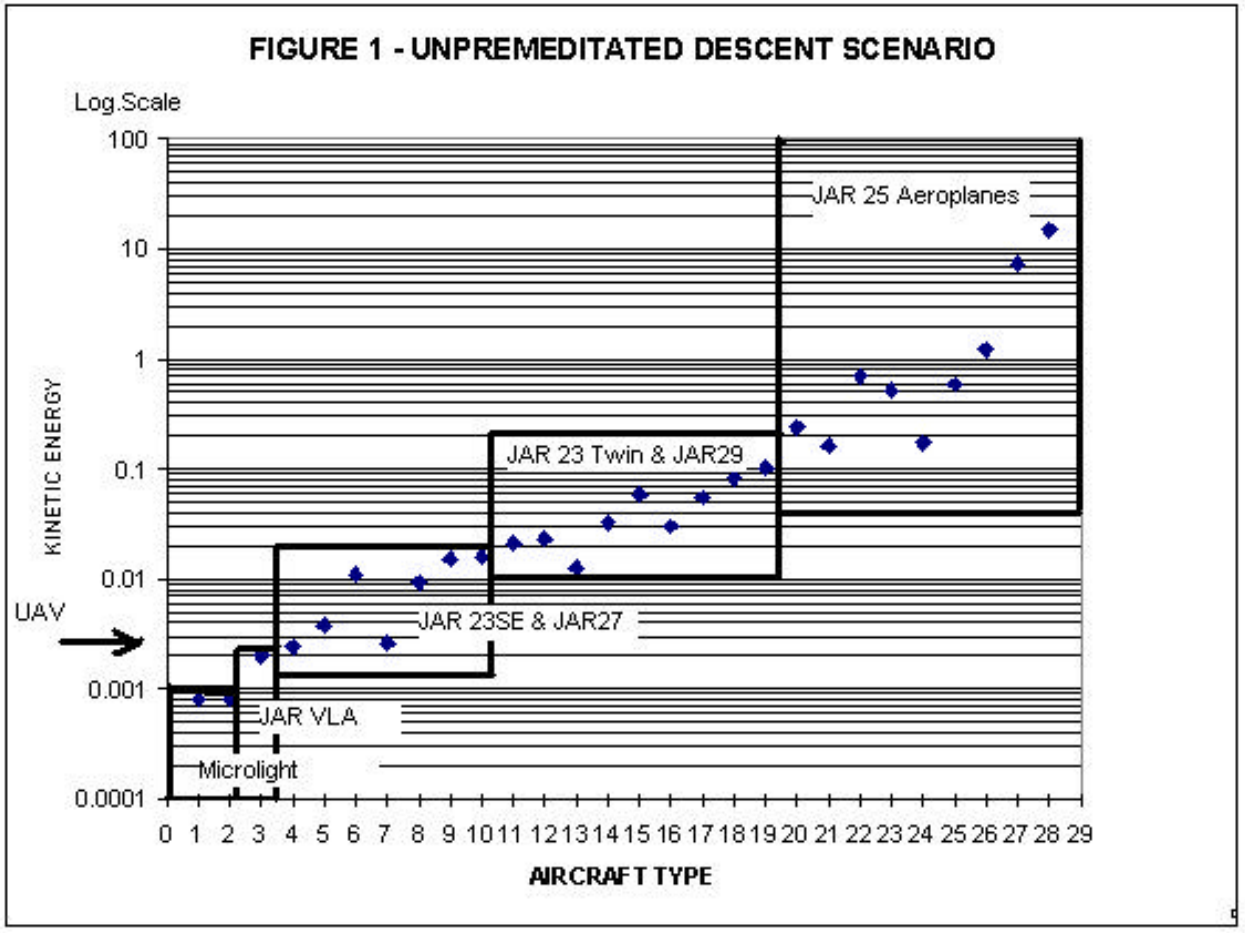
- Impact with the surface at a velocity appropriate to an emergency landing under control; (Unpremeditated Descent Scenario)
- Impact at a velocity resulting from loss of control at altitude; (Loss of Control Scenario)

Calculate the kinetic energy for each impact for the UAV and compare with similar calculations made for a wide range of certificated manned aircraft -

Airworthiness of Civil UAVs

Comparison in terms of kinetic energy at impact

(Schematic example only; for actual figures see Paper)



Airworthiness of Civil UAVs

CAA method for obtaining a first estimate of the appropriate airworthiness standards - continued

- Compare the UAV with the manned fleet for each scenario – then choose the appropriate types of requirement to address (1) forced landing, and (2) loss of control, to the appropriate level.
- Add outline Special Condition paragraphs to address novel features, (e.g. remote guidance)
- Start refining this first estimate into an appropriate set of requirements

Airworthiness of Civil UAVs

CAA method for obtaining a first estimate of the appropriate airworthiness standards - continued

- This method is not a solution – just a starting point!
- It does not oblige the CAA to agree to any particular standard.
- Precise calculation is not appropriate – The scale of the kinetic energy graph is logarithmic – We are looking at orders of magnitude.
- It is a useful tool to start the process of compiling the certification basis.

Airworthiness of Civil UAVs

Regulation of Design, Production and Maintenance

For a Certificate of Airworthiness to be valid the design requirements must be complied with, and

- The Design Organisation must be approved by the appropriate National Airworthiness Authority.
- The Production Organisation must be approved by the appropriate National Airworthiness Authority.
- There will need to be appropriate arrangements to ensure the UAV System is correctly maintained and remains in conformity with the approved design.

Airworthiness of Civil UAVs - Summary

Complete UAV Systems will be required to qualify for Certificates of Airworthiness, by

- Demonstration of compliance with airworthiness standards derived from existing manned aircraft requirements.
- The civil certification will include any system components remote from the aircraft which support or can affect airworthiness
- Organisations which design or manufacture civil UAV Systems will have to be approved under JAR 21 or similar requirements

Airworthiness of Civil UAVs - Summary

The primary reasons for adopting this position are:

- Using airworthiness standards derived from existing manned aircraft requirements facilitates common standards – (International flight; Export sales).
- Type Certification reduces the re-certification required on modification for role/mission changes.
- The use of airworthiness standards derived from existing manned aircraft requirements of gives confidence that the “no greater risk” objective will be satisfied.
- The application of comprehensive codes of requirements avoids additional operational limitations and hence a potential direct conflict between safety and commercial considerations.

Airworthiness of Civil UAVs

Questions?